

# PATENT SPECIFICATION

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 NILS HAGERT GÖTE STADMARK



## (54) PLATE FOR A PLATE HEAT EXCHANGER

- (71) We, ALFA LAVAL AKTIE- to define a plurality of channels for the heat  
 BOLAG, a Swedish Corporate Body, of Post- exchanging media, each of which channels  
 fack, S-140 00, Tumba Sweden, do hereby extends past a number of grooves or ridges  
 declare the invention, for which we pray that 50 respectively, in the plate.
- 5 a patent may be granted to us, and the method  
 by which it is to be performed, to be particu-  
 larly described in and by the following state-  
 ment:—
- 10 This invention relates to heat exchanger  
 plates having spacing members in the form of  
 protuberances and depressions in the heat ex-  
 changing surface.
- Such protuberances and depressions gener-  
 ally serve to create with reference to a desired  
 15 heat transfer coefficient a disturbance of the  
 flow of the heat exchanging media across the  
 heat exchanging surfaces. Some of the spac-  
 ing members in the heat exchanging surfaces  
 may be of the kind adapted to create only  
 20 little disturbance of the flow of the heat  
 exchanging media. Spacing members of this  
 kind are desirable for instance in the so-called  
 distribution surfaces of a heat exchanging  
 media. It is also desirable sometimes to have  
 25 spacing members of this kind all over the heat  
 exchanging surfaces, particularly when the heat  
 exchanging media are to be subjected to only  
 a small pressure drop during their passage  
 through the plate heat exchanger. Ideal heat  
 30 exchanger plates of this kind are difficult to  
 provide, however, for the greater free area  
 that is left for the flow of the heat exchang-  
 ing media across the plates, the less strength  
 the plates will have to resist differences in  
 35 pressure between the heat exchanging media.
- According to the invention there is provided  
 a plate for a plate heat exchanger, wherein  
 the heat transferring part of the plate com-  
 prises a plurality of side-by-side ridges  
 40 pressed up from a plane of the plate, and of  
 side-by-side grooves forming an angle with  
 the ridges and depressed from the same plane  
 of the plate, the ridges on one side of the  
 plate as well as the ridges on the other side  
 45 of the plate formed by the depressed grooves  
 being arranged, when two such plates are  
 brought into face-to-face abutting relationship,
- The bottom of each channel consists of a  
 number of parallelogram-shaped areas placed  
 one after the other in a rod, each of which is  
 surrounded along its four sides by the ridges  
 55 and grooves pressed in different directions.  
 The so-called limit of stretching strain for the  
 plate material is increased by the provision  
 of the ridges and grooves, which may be cold-  
 formed. 60
- The plate material can be made as thin as  
 possible for a given difference in pressure be-  
 tween two heat exchanging media, and for a  
 given flow resistance for these media in the  
 finished plate heat exchanger. This is of great  
 65 importance from material saving point of view  
 and also from the production point of view.  
 Also, for the heat transferring ability of the  
 heat exchanger plates it is important that they  
 are as thin as possible. 70
- The shape of the ridges and grooves may  
 vary in different ways. Thus, the ridges or the  
 grooves may extend without discontinuities  
 along the whole or at least a great part of  
 their length. Preferably, however, the ridges as  
 75 well as the grooves have discontinuities along  
 their lengths. In a preferred embodiment,  
 ridges and grooves which cross each other have  
 discontinuities at the common crossing points,  
 the portions of the plate at these discontinuities  
 80 preferably being situated in the same plane  
 as the previously mentioned plane of the plate.
- According to an alternative embodiment,  
 the design is such that the discontinuities of  
 the grooves are formed by the ridges, the  
 85 latter having discontinuities along their lengths  
 which are so placed that unbroken portions of  
 the plane of the plate extend parallel with  
 the grooves through discontinuities in the  
 ridges. 90
- It is not absolutely necessary that a plate  
 having an arrangement of spacing members as  
 described above is used together with plates  
 of the same kind in a plate heat exchanger.

However, the advantages of the described design are believed to be utilized in the best way if plates of the same kind are used. Then the ridges and the grooves should be so formed in each plate that when two plates are put together in a plate heat exchanger in a known manner ridges on one plate will abut, along the whole or a part of their length, corresponding parallel ridges on the other plate.

Several embodiments of a heat exchanger plate in accordance with the invention will now be described with reference to the accompanying drawings. In the drawings:—

Figure 1 shows a part of one embodiment of the heat exchanger plate;

Figures 2 and 3 are sectional views taken along the lines A—A and B—B, respectively, of Figure 1;

Figure 4 is a sectional view through three co-operating plates according to Figure 1;

Figures 5 to 8 are views corresponding to those of Figures 1 to 4 of a second embodiment;

Figures 9 to 12 are views corresponding to those of Figures 1 to 4, of a third embodiment;

Figures 13 and 14 show sectional views of different embodiments of the heat exchanger plate;

Figure 15 shows a plate adapted for heat exchange according to the so-called cross flow principle;

Figure 16 shows a plate adapted for heat exchange according to the so-called parallel flow principle;

Figure 17 shows the plate of Figure 16, but with ridges and grooves arranged as shown in Figure 1;

Figure 18 shows two co-operating plates according to Figure 17; and

Figures 19 to 21 are sectional views taken along the lines k—k, l—l and m—m, respectively, of Figure 18.

The embodiment of the plate shown in Figures 1 to 4 has a plurality of side-by-side ridges 1 pressed up from a plane 2 of the plate, and a plurality of side-by-side grooves 3, forming an angle  $\alpha$  with the ridges 1, depressed from the same plane 2 of the plate. As can be seen from Figure 1, the ridges 1 are continuous along their lengths, while the grooves 3 are interrupted along their lengths by the ridges 1. The pressed-up ridges 1 define between them upwardly open channels 4 (Figure 3), the bottoms of which are substantially constituted by the plane 2 of the plate. The bottoms of the channels 4 are formed by several parallelogram-shaped areas arranged in a row one after the other between the ridges 1.

On the other side of the plate, where the depressed grooves 3 form ridges, which like the grooves have discontinuities along their lengths, similar channels 5 (Figure 2) are formed having the plane 2 of the plate as

their bottom. The channels 5 extend between the ridges on this side of the plate, which are formed by the grooves 3.

Thus, the plate has on one side a plurality of parallel channels 4, and on the other side a plurality of channels 5 forming an angle with the channels 4. The channels 4, 5 form flowpaths along their respective longitudinal directions for the flow of two heat exchanging media separated by the plate.

Figure 4 shows how three heat exchanger plates, each constructed as shown in Figure 1, define together two adjacent flow passages in a plate heat exchanger. The three plates are in the drawing designated A1, B1 and C1. Each plate is turned 90° in its own plane relative to the adjacent plate. In the arrangement shown in Figure 4 this means that the unbroken ridges 1 of the plates A1 and C1, which are turned in the same direction, extend parallel and are situated just above each other, i.e. in the plane of the drawing, while the unbroken ridges 1 of the plate B1 extend perpendicular to the ridges of plates A1 and C1. As can be seen from the drawing, the underneath side of the grooves 3 of the plate A1 extend parallel with and abut the pressed-up ridges 1 of the plate B1, while the underneath side of the grooves 3 of the plate B1 extend parallel with and abut the pressed-up ridges 1 of the plate C1. Thus, each of the channels 5 of the plate A1 forms together with a corresponding channel 4 of the plate B1 a substantially closed channel 6 between the plate A1 and B1. Similarly, closed channels are formed between the plates B1 and C1 by the channels 5 of the plate B1 and the channels 4 of the plate C1.

Figure 5 shows a second embodiment of the plate and the difference between this embodiment and that according to Figure 1 is that the pressed-up ridges 1 are not continuous over their lengths, but like the depressed grooves 3 have discontinuities at intervals along their lengths. The discontinuities need not necessarily be situated at regular intervals as shown in this embodiment. The discontinuities in the lengths of the ridges 1, which in the drawing are designated 7, are situated on opposite sides of the parallelogram-shaped areas which form the bottom of the channels 4 between the ridges 1. The parts of the plate situated at the discontinuities 7 are in the same plane as the parallelogram-shaped areas, and therefore unbroken parts of the plane 2 of the plate extend parallel with the grooves 3 between the ridges 1.

Figure 8 shows a section corresponding to that in Figure 4 but showing three plates A2, B2 and C2 constructed as shown in Figure 5. A third embodiment of the plate is shown in Figure 9, and the difference between this embodiment and that shown in Figure 5 is that the discontinuities in the pressed-up ridges 1 are situated where the ridges 1

cross the grooves 3 instead of between these grooves. The discontinuities are in this embodiment designated 8, and the parts of the plate situated at the discontinuities 8 are in the same plane as the parallelogram-shaped areas between the ridges 1 and the grooves 3, i.e. in the previously-mentioned plane 2 of the plate. This can be seen from Figures 10 to 12.

Figure 12 shows a section corresponding to the sections in Figures 4 and 8 but of three plates A3, B3 and C3 constructed as shown in Figure 9.

In all of the above-described embodiments the parallelogram-shaped areas between the ridges 1 and the grooves 3 are entirely plane. This is not absolutely necessary, and as shown in Figures 13 and 14 these areas may be stiffened by being bent in one or the other direction or provided with protuberances. Further, these parts of the plate, as will be evident from the following, need not be situated exactly midway between the crests of the ridges 1 and the underneath sides of the grooves 3. By forming and placing the parallelogram-shaped areas of the plate differently, it is possible to change the flow conditions for the heat exchanging media flowing across the plate.

Figures 15 and 16 show two kinds of heat exchanger plates, wherein a design according to Figures 1 to 14 can be used.

Figure 15 shows a so-called cross flow plate, in which a first heat exchanging medium is intended to flow across the plate on one side of it from an inlet 9 to an outlet 10, while a second heat exchanging medium is intended to flow on the other side of the plate, crossing the flow direction of the first medium, from an inlet 11 to an outlet 12. The ridges 1 and grooves 3 are illustrated in the drawing by dashed lines. In a package of plates of this kind, every second plate is turned 90° in its own plane relative to its adjacent plates, so that the ridges of one plate will extend parallel with and abut the underneath side of the grooves of the adjacent plate. It is also possible that every second plate is turned around, i.e. turned 180° about an axis extending in the plane of the plate.

A heat exchanger plate adapted for substantially concurrent or counter-current flow heat exchange is shown in Figure 16. The heat transferring area of this plate is divided into three areas F, G and H, which have different kinds of turbulence effecting protuberances and depressions. The plate has an inlet 13 and an outlet 14 for a first heat exchanging medium which is intended to flow on one side of the plate, and an inlet 15 and an outlet 16 for a second heat exchanging medium which is intended to flow on the opposite side of the plate (counter-current flow heat exchange). For defining flow passages between adjacent plates in a plate heat exchanger

each plate has a strip seal 17. The flow of the first heat exchanging medium from the inlet 13 to the outlet 14 is illustrated by arrows 18.

The object of the above-mentioned division of the heat transferring surface of the plate into areas having different designs of the turbulence effecting members is that the heat exchanging media should be distributed in the best way over all the width of the heat transferring surfaces in their passage between the inlets and the outlets. To achieve this, the so-called distribution surfaces F and H are provided with turbulence effecting members so formed that the flow resistance for the medium entering through the inlet 13 and the inlet 15, is substantially less in these distribution surfaces than in the central part G of the plate, which latter part constitutes the real heat exchanging surface of the plate. The effects of certain portions of the heat exchanging media flowing a longer way than other portions across the distribution surfaces are thus reduced.

The previously described arrangement of the pressed-up ridges 1 and depressed grooves 3, forming an angle therewith, is in such heat exchanger plates especially intended to be used for the so-called distribution surfaces F and H.

Figure 17 shows a heat exchanger plate P1 of the same kind as that in Figure 16, in which the distribution surfaces F and H are provided with pressed-up ridges 1 (full lines) and depressed grooves 3 (dashed lines). The squares formed on the plates by these ridges and grooves constitute the previously mentioned parallelogram-shaped areas. One of the ridges in the distribution surface F is designated 19, and one of the ridges in the distribution surface H is designated 20. In the distribution surface F, in the area between the ridge 19 and the opening 16, the plane 2 of the plate, i.e. the plane of the parallelogram-shaped areas, has been displaced a distance  $a$  perpendicular to the plane of the plate, so that the pressed-up ridges 1 have a height above the plane 2 of the plate which exceeds the distance between the plane 2 of the plate and the underneath sides of the depressed grooves 3 by  $2 \times a$ . Over the rest of the distribution surface F the plane 2 of the plate is situated in the middle between the crests of the ridges and the underneath sides of the grooves. In the distribution surface H the plane 2 of the plate is similarly displaced in the area between the ridge 20 and the opening 15.

When superimposing one heat exchanger plate on another, such as they will be put together in a plate heat exchanger, i.e. with one plate turned 180° in its own plane relative to the other, two distribution surfaces F and H will co-operate in the manner described below. Figure 18 shows the plate P1 of

Figure 17, and a similar plate P2, the latter being turned through 180°. When the plates P1 and P2 are put together, the ridge 19 of the plate P1 will cross the ridge 20 of the plate P2 in the way that can be seen from Figure 18, such that four different areas K, L, M and N are defined within the two co-operating distribution surfaces F and H.

Figures 19 to 21 show sections through the two co-operating plates P1 and P2 along the lines k—k in the area K, l—l in the area L and m—m in the area M, respectively, in Figure 18. The two plates P1 and P2 are assumed to have in their distribution surfaces an arrangement of ridges and grooves as shown in Figure 1. If then the thickness of the plates P1 and P2, i.e. the distance between the plane of the crests of the ridges 1 and the plane of the underneath sides of the grooves 3, is designed S, the width of the interspace between the plates, i.e. the height of the channels 6 (see Figures 4, 8, 12), owing to the previously mentioned displacement  $a$  of the plane 2 of the plate in certain parts of the distribution surfaces F and H, will be  $S-a$  in the area K,  $S$  in the area L, and  $S+a$  in the area M. In the area N the plane 2 of the plate of both plates is situated in the middle between the two said planes for the crests of the ridges and the underneath sides of the grooves, and therefore the width of the plate interspace will be  $S$ . (For the sake of simplicity no consideration has been given to the plate material thickness in the above calculations of the plate interspace width).

Consequently, for liquid that is to flow in the interspace between the plates P1 and P2 in Figure 18 from the inlet 13 to the heat exchanging surfaces G of the plates, a greater flow resistance will arise in the area K of the distribution surfaces (see Figure 19) than in the areas L (Figure 20) and M (Figure 21).

By suitable forming of the distribution surfaces F and H it is thus possible to obtain a distribution of liquid entering through the inlet 13 (or the inlet 15) in a desired manner all over the width of the plates P1 and P2.

#### WHAT WE CLAIM IS:—

1. A plate for a plate heat exchanger, wherein the heat transferring part of the plate comprises a plurality of side-by-side ridges pressed up from a plane of the plate, and of side-by-side grooves forming an angle with the ridges and depressed from the same plane of the plate, the ridges on one side of the plate as well as the ridges on the other side of the plate formed by the depressed grooves being arranged, when two such plates are brought into face-to-face abutting relationship to define a plurality of channels for the heat exchanging media, each of which channels ex-

tends past a number of grooves or ridges, respectively, in the plate.

2. A plate according to claim 1, wherein at least some of the grooves each have one or more discontinuities along their lengths.

3. A plate according to claim 2, wherein at least some of the pressed-up ridges have discontinuities along their lengths.

4. A plate according to claim 3, wherein crossing ridges and grooves have discontinuities at the common crossing points.

5. A plate according to claim 3, wherein the discontinuities of the grooves are formed by the ridges which have discontinuities along their lengths so situated that unbroken portions of the plane of the plate extend generally parallel with the grooves through the discontinuities in the ridges.

6. A plate according to any of claims 2 to 5, wherein the parts of the plate situated at the said discontinuities are in the same plane as the said plane of the plate.

7. A plate according to any of the preceding claims, wherein the pressed-up ridges and the grooves are straight.

8. A plate according to any of the preceding claims, wherein the grooves extend perpendicular to the ridges.

9. A plate according to any of the preceding claims, wherein the plane of the plate is provided with protuberances and/or depressions in the portions which form the bottoms of the channels.

10. A plate according to any of the preceding claims, wherein the ridges and the grooves extend along the plate in such a manner that when two plates are mounted in a plate heat exchanger, ridges on one plate abut along the whole or a part of their lengths against ridges on the other plate and extend parallel thereto.

11. A plate according to any of the preceding claims, having two pairs of openings for respective heat exchanging media, the two openings for the same medium being situated at the same edge of the plate, wherein the plate has distribution surfaces adjacent the respective openings of one pair in which the pressed-up ridges extend away from the openings towards the opposite edge of the plate.

12. A plate according to claim 11, wherein in the part of the distribution surface situated adjacent the inlet opening for one medium between said inlet opening and the opposite edge of the plate, the plane of the plate is so displaced in the direction perpendicular to the plate that the channels formed between the pressed-up ridges are deeper along the whole or a part of their lengths than the channels between the ridges situated along the shortest flowpath between the said inlet opening and the heat exchanging surface of the plate between said distribution surfaces.

13. A plate for a plate heat exchanger constructed and arranged substantially as herein described with reference to Figures 1 to 3,

5 to 7, or 9 to 11, or as modified by Figure 13 or 14, or to Figures 15, 16 or 17.

14. A heat exchanger comprising two or more plates according to any of the preceding claims.

- 5 15. A heat exchanger constructed and arranged substantially as herein described with reference to Figures 4, 8, 12 or 18 to 21 of the accompanying drawings.

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7 SHEETS

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Sheet 1

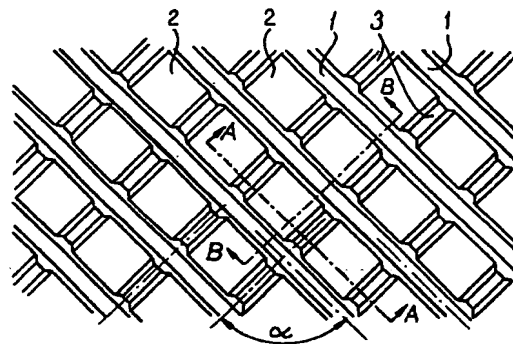


Fig. 1

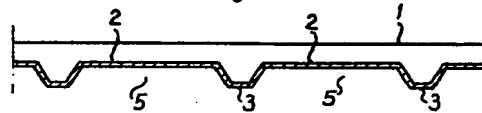


Fig. 2 (A-A)

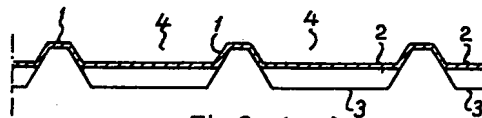


Fig. 3 (B-B)

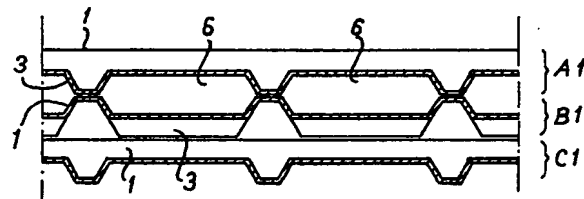


Fig. 4

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Sheet 2

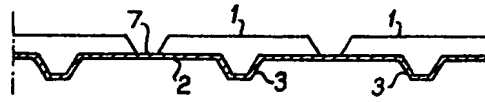
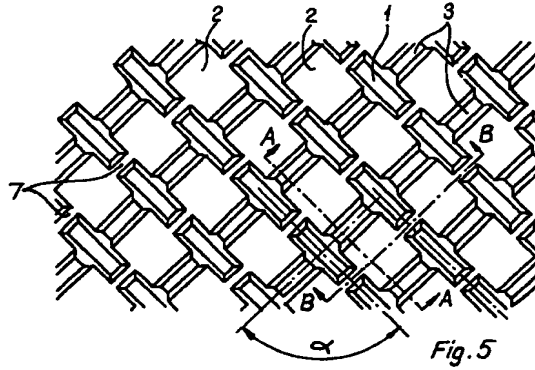


Fig. 6 (A-A)

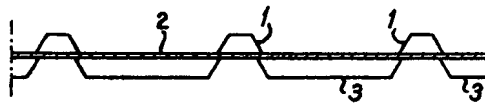


Fig. 7 (B-B)

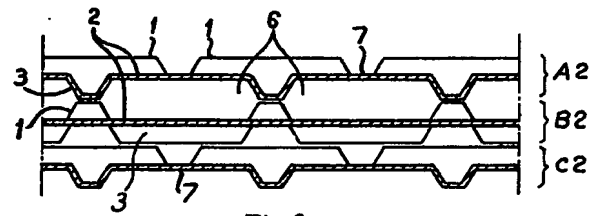


Fig. 8

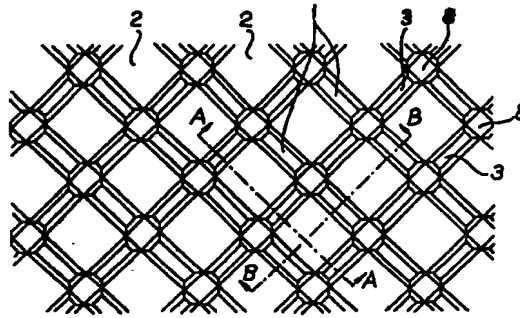


Fig. 9

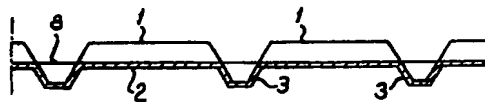


Fig. 10 (A-A)

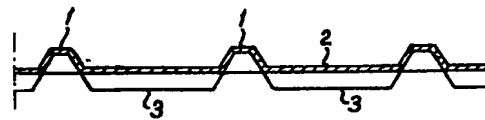


Fig. 11 (B-B)

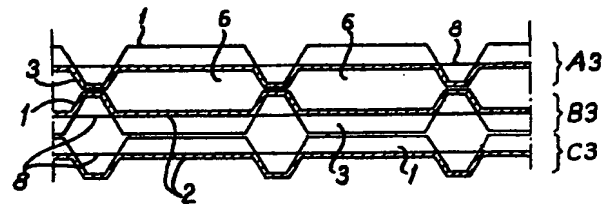


Fig. 12

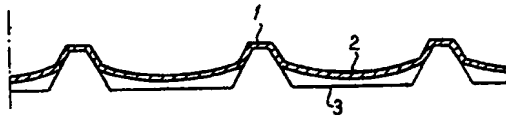
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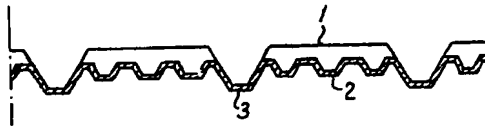
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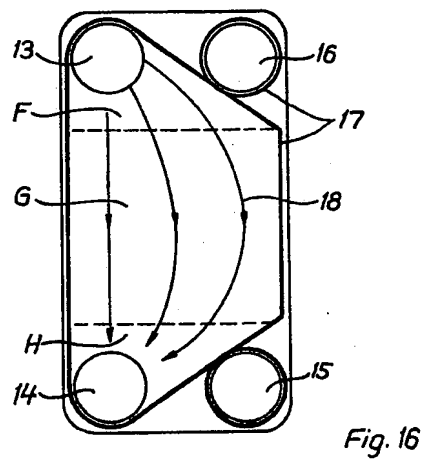
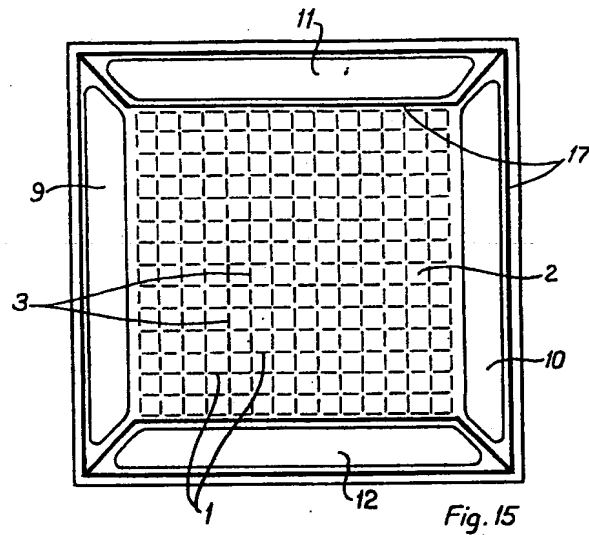
Sheet 4



*Fig. 13*



*Fig. 14*



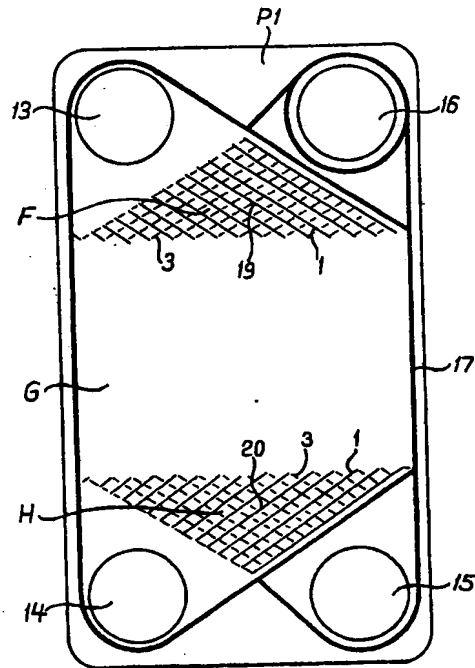


Fig. 17

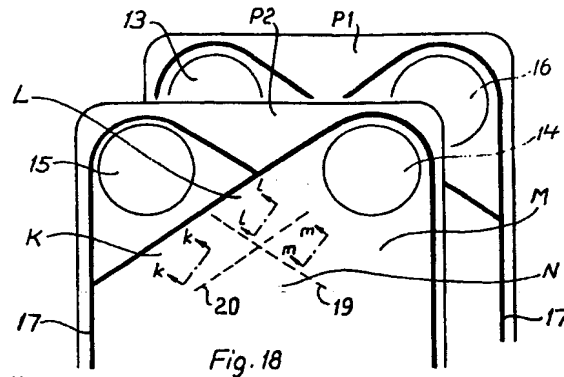


Fig. 18

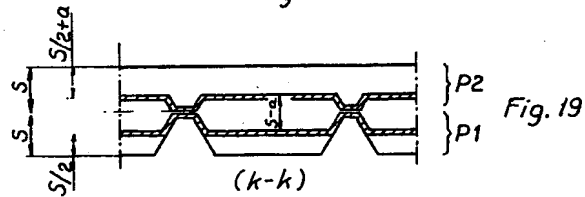


Fig. 19

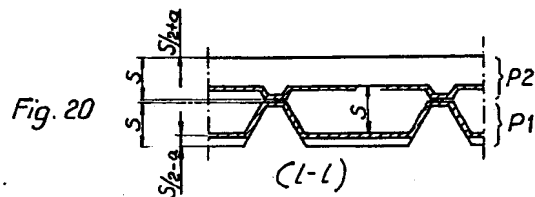


Fig. 20

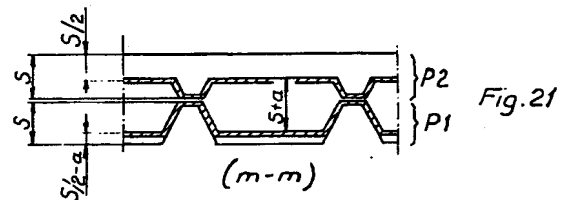


Fig. 21